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Attorney Docket No. 3600.100

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Reissue Application of :	Examiner: Not yet assigned
DAVID A. SPEAR ET AL. :	Group Art Unit: 3745
Appln. No.: 09/343,736 :	
Filed: June 30, 1999 :	
For: SWEPT TURBOMACHINERY BLADE :	Date: January 5, 2000

Assistant Commissioner for Patents
Washington, D.C. 20231

INFORMATION DISCLOSURE STATEMENT

Sir:

In compliance with the duty of disclosure under 37 C.F.R. § 1.56 and in accordance with the practice under 37 C.F.R. § 1.97 and 1.98, the Examiner's attention is directed to the documents listed on the enclosed Form PTO-1449. Copies of the listed documents are also enclosed.

It is respectfully requested that this information be considered by the Examiner and that a copy of the enclosed Form PTO-1449 be returned indicating that such information has been considered.

I. INTRODUCTION

The claims in the present application all recite turbomachinery blades for a turbine engine. Typically, plural blades are arranged so that neighboring blades form passages for

a working medium gas. Certain operational conditions of the engine produce supersonic flow velocities in regions of the working medium gas. Although supersonic flow has more energy than subsonic flow (in the form of increased momentum), it also creates shocks in the flow. See the present specification at page 3, lines 30-57; Figures 3, 5 and 7; Declaration of Harris D. Weingold Under 37 C.F.R. § 1.132 ("the Weingold Declaration") at paragraph 6.

Before the present invention, those skilled in the art knew that introducing so-called sweep into the leading edge of a turbomachinery blade reduced momentum losses introduced by shocks in the interblade passages, the reason being that a swept blade forms shocks that are oblique to the direction of the fluid flow. An oblique shock creates less momentum loss, so a swept supersonic turbomachinery blade generally is more efficient than an unswept counterpart. However, the configuration of prior art swept blades introduced operational inefficiencies of their own, caused at least in part by multiple shocks and shocks outside of the passages between neighboring blades. The applicants' invention comprises a blade with structure that can avoid the inefficiencies and instabilities introduced by prior art swept blades. Weingold Declaration at paragraph 7.

II. THE CLAIMS

Claims 1-41 are in the application. Claims 1, 2, 4, 10, 18, 20, 27, 30 and 36 are independent. The following discussion focuses on the independent claims, taking each in

turn. The applicants' dependent claims are patentable in their own right, although they are not discussed in detail to avoid making this Information Disclosure Statement unduly lengthy. However, by not discussing the separate patentability of the dependent claims the applicants do not mean to imply that such claims rely solely on the features of their respective independent claims for patentability. Accordingly, the Examiner is requested to consider all of the claims on their individual merits.

A. Original Claims 1-3

The majority of the documents listed on the enclosed Form PTO-1449 were of record during the prosecution of the original Application No. 08/559,965 ("the Original '965 Application") that issued as U.S. Patent 5,642,985, which the present application seeks to reissue. Since claims 1-3 have not been changed, it is submitted that they are patentable over those documents for the same reason they were allowed in the Original '965 Application. That is, none of them would have suggested a blade leading edge swept to intercept an endwall shock so that endwall and passage shocks are coincident.

Many of the prior art documents listed on the enclosed Form PTO-1449 disclose turbomachinery blades, some of which cause the working medium gas to attain supersonic velocities in at least some regions of the flow over the blades and through the blade cascade. Weingold Declaration at paragraph 8.

Independent claims 1 and 2 recite blades in which a radially outward region of the blade leading edge is swept such that a section of the blade radially coextensive with an endwall shock extending from a neighboring blade intercepts the endwall shock so that it and a passage shock extending across the flow passage are coincident. The subject matter of claims 1 and 2 would not have been obvious from any of the listed documents relating to turbomachinery blades because none of them would have suggested to one of ordinary skill in this art a blade leading edge swept to intercept an endwall shock so that endwall and passage shocks are coincident. Weingold Declaration at paragraphs 9 and 10.

The enclosed Form PTO-1449 lists several documents that were not cited during pendency of the Original '965 Application. Two were cited in the European Search Report in European Appln. 96308030. (That European application, which claims priority from the Original '965 Application, was published as EP 774567 and is listed as such on the enclosed Form PTO-1449.) One such document is WO 91/07593, which corresponds to listed U.S. Patent 5,064,345 ("the Kimball '345 Patent"), and the other is French Patent 2,459,387 ("the French '387 Patent"; citations herein are to the enclosed English translation.) Copies of the European Search Report and of an official communication from the European Patent Office in that application are enclosed for the Examiner's information.

The Kimball '345 Patent shows a ventilation-type fan with blades having a leading edge profile similar to the rear swept embodiment shown in Figure 2 of the present application. It discloses a blower-type fan for a heat exchanger or for forced air heating, as explained, for example, at column 1, lines 4-8. However, it contains no teaching that would have been instructive to one of ordinary skill in the art regarding turbomachinery blades for turbine engines. Weingold Declaration at paragraph 11.

Although the Kimball '345 Patent shows a blade with a swept leading edge, that blade is not suitable for use in a turbine engine, let alone one having blades that rotate fast enough to produce regions of supersonic flow. It even suggests at column 3, lines 22-23, that the fan be manufactured "by conventional plastic molding techniques," which would preclude its rotation at speeds required for use in a turbine engine or that would produce relative supersonic flow over a portion of the blade. Therefore, the Kimball '345 Patent does not disclose a turbomachinery blade for a turbine engine in which shocks form in the flow. Weingold Declaration at paragraph 12.

The preferred embodiment of the Kimball '345 Patent's fan has an outer band 20, which is intended to improve the strength of the fan. However, providing such a band would not render a fan with the structure disclosed in the Kimball '345 Patent capable of rotation at speeds required for use in a

turbine engine or that would produce relative supersonic flow over a portion of the blade. The Kimball '345 Patent mentions at column 3, lines 30-31, that its fan need not include a band, but in that event the resulting blade would have a configuration even more clearly incapable structurally of being rotated at speeds producing supersonic flow velocities in at least some regions of the flow over the blades. Weingold Declaration at paragraph 13.

As a result, one of ordinary skill in the art would not have found the subject matter of claims 1 and 2 obvious from the Kimball '345 Patent. Weingold Declaration at paragraph 14.

The French '387 Patent shows a ventilation-type fan with blades having a leading edge profile similar to the forward swept embodiment shown in Figure 6 of the present application. It is representative of other prior art that shows this type of ventilation fan, such as U.S. Patents No. 1,964,525 and No. 4,737,077. Weingold Declaration at paragraph 15.

Like the Kimball '345 Patent, the configuration of the ventilation fan in the French '387 Patent would preclude its rotation at speeds required for use in a turbine engine or that would produce relative supersonic flow over a portion of the blade. Moreover, the use of bolts to attach the blades to the hub, as seen in Figures 1 and 2, also would precludes their rotation at speeds that would achieve relative supersonic flow in at least some regions of the flow over the blades. Weingold Declaration at paragraph 16.

As a result, one of ordinary skill in the art would not have found the subject matter of claims 1 and 2 obvious from the French '387 Patent. Weingold Declaration at paragraph 17.

Another listed document not of record in the Original '965 Application is Puterbaugh et al., "Design of a Rotor Incorporating Meridional Sweep and Circumferential Lean for Shock Loss Attenuation," Contract AFWAL-TR-86-2013, February 1987, Aero Propulsion Laboratories, Air Force Wright Aeronautical Laboratories, Wright-Patterson Air Force Base, Ohio ("the Puterbaugh Report"), reports the results of analytical design studies of the shock losses in swept blades in a turbomachinery rotor. In particular, it reports such studies on a swept rotor blade with increased "circumferential lean," which produced a blade having a leading edge with an aerodynamic sweep angle distribution plotted by the lower line in Figure 5 of the Puterbaugh Report, as described below.

The Puterbaugh Report uses the term "aerodynamic sweep angle" in generally the same manner as the present application. That is, aerodynamic sweep angle is a term known to those skilled in this art as referring to the angle formed by the blade leading edge and a plane normal to the relative velocity vector of the working medium gas. That is how the term is used in the present application. See the "sweep angle σ" shown in Figure 4 and defined at page 3, lines 20-29, of the present application. Weingold Declaration at paragraph 18.

The Puterbaugh Report contains no teaching regarding the development of endwall shocks or providing a blade with a leading edge swept to intercept endwall shocks. Therefore, it fails to suggest the blade of claim 1 or 2, with a leading edge swept to intercept an endwall shock so that endwall and passage shocks are coincident. Weingold Declaration at paragraph 19.

Figure 5 of the Puterbaugh Report contains two plots of for the blade discussed in the report. The table in the Puterbaugh Report beginning at the bottom of page 133 and extending to page 134 describes the distribution of the aerodynamic sweep angle along the leading edge ("LE Sweep") and the aerodynamic sweep angle of the passage shock as it intersects the blade suction surface ("Shock Sweep @ Suct Surf"). Comparing these distributions reveals that the magnitude of Shock Sweep @ Suct Surf is greater than that of LE Sweep at every blade radius. These distributions are plotted in Figure 5 as functions of the normalized blade radius, so that it is evident that the upper line in Figure 5 represents Shock Sweep @ Suct Surf and the lower line represents LE Sweep. Accordingly, the upper line does not represent the sweep angle of the blade's leading edge, as recited in the applicants' claims, and one skilled in the art would not have found it to suggest a blade leading edge swept as recited in the applicants' claims. Weingold Declaration at paragraph 20.

As noted above, the lower line in Figure 5 represents the sweep angle of the leading edge of the Puterbaugh Report's

blade. However, that sweep angle begins increasing from a point about 35% of the way from the blade's root end to its tip end, which point is comparable to the beginning of the intermediate region of the blade disclosed in the present application (see, for example, Figure 2). Once it begins to increase at that point, the sweep angle of the leading edge of the Puterbaugh Report's blade increases all the way to the tip.

In contrast, a preferred embodiment of the present invention's blade has a leading edge sweep angle that decreases in a tip region, or put another way, has a leading edge with a tip region that is translated in a direction opposite to that of the sweep of the leading edge intermediate region. Such a configuration provides more efficient operation, in one embodiment enabling the blade to intercept an endwall shock so that endwall and passage shocks are coincident. The Puterbaugh Report does not disclose that blade structure. Accordingly, a blade with the leading edge swept as shown in the lower line of Figure 5 of the Puterbaugh Report also fails to suggest the blades of claims 1 and 2, with a leading edge swept to intercept an endwall shock so that the endwall and passage shocks are coincident. Weingold Declaration at paragraph 21.

Cheatham et al., "Parametric Blade Study," Report No. WRDC-TR-89-2121, November 1989, Aero Propulsion and Power Laboratory, Wright Aeronautical Research & Development Center, Wright-Patterson Air Force Base, Ohio ("the Cheatham Report") listed on the enclosed Form PTO-1449 contains photographs of

various turbomachinery blades, having varying degrees of leading edge sweep, tested by the United States Air Force in the 1970's. Figures B18, B19 and B20 are photographs of the blade discussed in the Puterbaugh Report. Weingold Declaration at paragraph 22. The Cheatham Report is enclosed so that the Examiner will be able further to appreciate the configuration of the Puterbaugh Report's blade. None of the other blades depicted in the Cheatham Report are believed to be relevant to the present invention. Examination of the front and side views of the Puterbaugh Report's blade (Cheatham Report Rotor 7), and of the other rotors depicted in the Cheatham Report, reveals no feature suggesting the particular leading edge sweep distribution that is a salient feature of the present invention. Weingold Declaration at paragraph 22. However, the applicants will be happy to answer any questions the Examiner may have concerning any of those blades.

There are other prior art patents listed on the enclosed Form PTO-1449 that show various blade shapes used in different applications, such as ventilation fans (U.S. Patents No. 2,154,313, No. 3,416,725 and No. 4,737,007, and Soviet Patent SU 1,528,965), a fluid pump (U.S. Patent No. 3,444,817) a mixing impeller for blending liquids (U.S. Patent No. 5,112,192), aircraft prop fans (U.S. Patents No. 4,370,097 and No. 4,358,246) and helicopter rotor blades (U.S. Patent No. 5,584,661). None of them disclose turbomachinery blades like those recited in the

applicants' claims, or solve (or even recognize the existence of) the problems capable of solution by the blades recited in the applicants' claims. As a result, one of ordinary skill in the art would not have found the invention of claims 1 and 2 obvious from any of those references. For example, U.S. Patent No. 5,584,661 discloses a swept helicopter rotor blade in which shocks form in the blade tip region. However, the sweep profile of the blade is unlike that of the turbomachinery blade of the present invention and is incapable of suggesting to one of ordinary skill in the art a turbomachinery blade with a leading edge swept to intercept an endwall shock or so that endwall and passage shocks are coincident. Weingold Declaration at paragraph 23.

Accordingly, independent claims 1 and 2, and their dependent claim 3, are patentable over the prior art.

B. New Claims 4-41

Independent claim 4 is directed to a turbomachinery blade for a gas turbine engine fan comprising a plurality of such blades in which neighboring blades form passages for a working medium gas. The blade is configured to enable the fan to rotate at speeds that provide supersonic flow velocities in at least a portion of the interblade passages, causing a shock adjacent the inner wall of a case that forms the outer boundary for the working medium gas. The blade leading edge has a rear swept intermediate region and a tip region that is translated forward

(as shown in Figure 2) to provide a sweep angle that causes the blade to intercept the shock.

Claim 4 is patentable for at least the reasons discussed above in connection with claims 1 and 2. That is, the prior art listed on the enclosed From PTO-1449, including that relating to turbomachinery blades, does not contain any suggestion of a supersonic turbomachinery blade with a intermediate region that is swept rearward and a tip region that is translated forward to provide a sweep angle that causes the blade to intercept a shock formed at the wall of a case. Weingold Declaration at paragraph 24.

Accordingly, claim 4, and its dependent claims 5-9, are patentable over the prior art.

Claim 10 recites a gas turbine engine fan blade also comprising a plurality of such blades in which neighboring blades form passages for a working medium gas. As in claim 4, the blade is configured to enable the cascade to rotate at speeds that provide supersonic flow velocities in at least a portion of the interblade passages.

The blade of claim 10 has a leading edge with a swept intermediate region and a tip region that begins at a radially outward boundary of the intermediate region and extends to a tip end of the blade. Throughout the tip region the leading edge sweep angle is less than it is at the beginning of the tip region (that is, at the intermediate region/tip region boundary). Claim 20 recites turbomachinery including a blade with this feature.

The subject matter of each of claims 10 and 20 would not have been obvious to one of ordinary skill in the art for reasons discussed above in connection with claims 1, 2 and 4. That is, none of the prior art listed on the enclosed Form PTO-1449, including that relating to turbomachinery blades, contains any suggestion of a supersonic turbomachinery blade with a tip region throughout which the leading edge sweep angle is less than it is at the tip region's boundary with an intermediate region. Weingold Declaration at paragraph 25.

In particular, the Examiner is directed again to Figure 5 of the Puterbaugh Report, which discloses a blade with a rearwardly swept leading edge. (Claims 10 and 20 relate to blades with either a rearward or forward swept intermediate region.) As noted above, the lower line represents the sweep angle of the blade's leading edge, which clearly does not include a region extending to the tip of the blade in which the sweep angle throughout such region is less than the sweep angle at the radially inner boundary of the region. This is more than simply a minor difference in blade structure, since it is the recited leading edge profile that provides the recited blade with the superior aerodynamic properties described in the present application. Weingold Declaration at paragraph 26.

Accordingly, claims 10 and 20, and their respective dependent claims 11-17 and 21-26, are patentable over the prior art.

Claims 18, 27 and 30 recite gas turbine engine blades with a rearward swept intermediate or middle region and a tip region that is translated forward from the intermediate region's outer boundary, at which the tip region begins. Claim 36 recites a gas turbine engine blade with a forward swept middle region and a tip region that is translated rearward from the middle region's outer boundary.

The subject matter of each of claims 18, 27, 30 and 36 is patentable for reasons discussed in detail above in connection with the other claims in the present application. That is, none of the prior art listed on the enclosed Form PTO-1449 discloses or suggests a supersonic turbomachinery blade with a leading edge that is swept in one direction (rearward or forward) and a tip region that is translated in the other direction from its boundary with the intermediate region. Weingold Declaration at paragraph 26.

Accordingly, claims 18, 27, 30 and 36, and their respective dependent claims 19, 28 and 29, 31-35 and 37-41, are patentable over the prior art.

III. ROLLS-ROYCE EP 801230

EP 801230, applied for by Rolls-Royce, plc ("Rolls-Royce EP '230"), is listed on the enclosed Form PTO Form-1449. It is not prior art to the present application, not having been published until October 15, 1997, well after the Original '965 Application was filed on November 17, 1995. Moreover, Rolls-

Royce EP '230 has a priority date of April 4, 1996, which is also after the filing date of the Original '965 Application.

The documents listed on the enclosed Form PTO-1449 include the prior art cited in the European Search Report of Rolls-Royce EP '230.

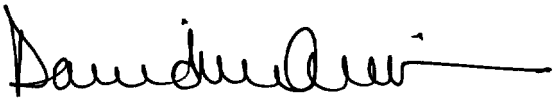
The Examiner will note that none of the claims of Rolls-Royce EP '230 are patentable over all of the claims in the present application. See 37 C.F.R. § 1.601(n). The applicants do not know whether or not there is a pending U.S. application corresponding to Rolls-Royce EP '230.

IV. SUMMARY

The applicants have made certain representations regarding the prior art. However, the Examiner is encouraged to study all of the prior art to ensure that the claims presented herein are patentable over same.

The applicant's undersigned attorney may be reached by telephone at (609) 921-8660. All correspondence should be directed to the below listed address.

Respectfully submitted,



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